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Detecting single ship plumes from TROPOMI NO_2 data

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This work focuses on studying signatures of individual ships in TROPOMI NO_2 observations. Information on ships, their location and NOx emissions, are obtained from the Ship Traffic Emission Assessment Model (STEAM, Jalkanen et al., 2009). For this work altogether 33 large container ships are selected that operated between Europe and Asia between May-October in 2018 and/or 2019. TROPOMI NO_2 data is sampled over the Mediterranean along each ships route provided by STEAM, allowing a maximum of 15 minutes temporal difference between the satellite observation and the ship location. Each of the matching TROPOMI NO_2 scene is analysed using the ships route information for the past 2 hours from the satellite observation.

For each container ship multiple matching observations are found where a signature of the ships emissions is visible in the TROPOMI NO_2 data. These signatures are seen both under sun glint and non-glint conditions, but under glint the signature is often more clear (Fig.1). Over the Mediterranean there aren't any significant differences at which month these signatures were observed, but only for few cases the match and a clear signature are obtained in consecutive days. However, there are also multiple cases when it was not possible to connect a plume to a specific ship, especially near the Strait of Gibraltar or locations where the shipping lane goes close to the coast. In this work also comparisons between the STEAM NOx emissions and TROPOMI NO_2 were carried out. In addition, meteorological conditions were analysed using ERA5 data. Preliminary results indicate that the R^2 value between STEAM NOx and TROPOMI NO2 is about 0.15-0.2 when signatures from all individual ships are combined, but for glint cases and high planetary boundary layer conditions R^2 is somewhat higher. These results are sensitive to the sampling method, and therefore more testing on modified sampling will be carried out. Next steps include also more detailed analysis of meteorological conditions.

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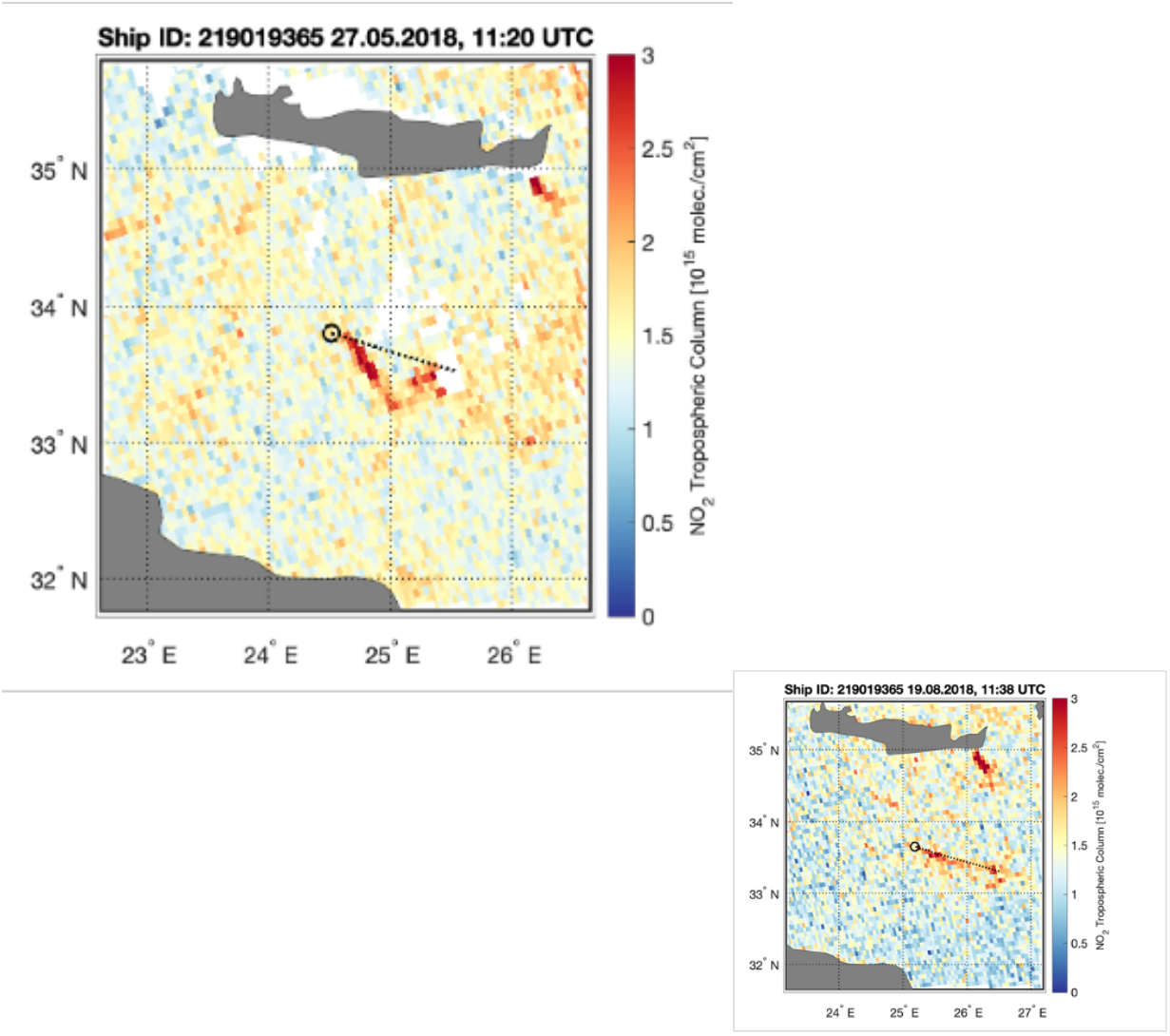

Figure 1. An example of a ship plume signature in TROPOMI NO_2 data, under glint (left) and non-glint (right) conditions. Black dot indicate the ship location within 15 min. the TROPOMI overpass, and the dotted line the ships route 2h prior to the overpass.

Reference: Jalkanen, J-P., Brink, A., Kalli, J., Pettersson, H., Kukkonen, J. and Stipa, T.: A modelling system for the exhaust emissions of marine traffic and its application in the Baltic Sea area", Atmos. Chem. Phys., 9, 9209□9223, 2009.